Science, Technology and Values: Promoting Ethics and Social Responsibility

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SCIENCE, TECHNOLOGY AND VALUES: PROMOTING ETHICS AND SOCIAL RESPONSIBILITY

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Abstract: The paper discusses the limitations of engineering ethics as frequently implemented in practice, with a focus on how activities are carried out without considering whether the activities are themselves ethical, and the gap between legality and ethics. This leads to the following three central ideas of the paper. The first is the need for engineers to both be aware of and critique their own values and to be able to widen their perspective to that of the 'other' i.e. marginalised and minority groups and the environment. This understanding of the 'other' and values is also applied to discussion of ethical issues relating to minority world ('developed') country engineers working in majority world ('developing') countries. The second central idea is the fact that structural and contextual factors in the form of barriers and enablers affect ethical values and practices. Individuals are not necessarily unethical in themselves, but the context and organisational ethos may present barriers to ethical behaviour and encourage the development of unethical values. These barriers and enablers are investigated through a pilot survey. The third central idea is the relationship between individual and collective responsibility and the need for support to enable engineers to think and behave ethically.

Keywords: Ethics, engineers, individual and collective responsibility, support, values, barriers and enablers.

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1. THE IMPORTANCE OF ENGNEERING ETHICS

Technology development is one of the most important factors in shaping modern society, both in the richer industrialised countries, which fairly quickly experience new technologies, and the poorer majority world countries, where access to new technologies is more restricted. Thus, engineers have the potential to both have a significant positive influence on society and cause very serious and possibly lasting damage. Being an engineer could be considered to be both a great privilege and a real responsibility. There is increasing awareness of ethical and social responsibility issues with regards to how engineers carry out their jobs, but less so with regards to the nature of these jobs. For instance, one of the case studies produced by a US National Science Foundation funded project on introducing ethics into engineering teaching considers the case of three civilian chemical engineers convicted for illegally storing, handling and disposing of hazardous waste while developing a new chemical weapon. This case study considers a range of ethical issues associated with hazardous chemicals, but not the ethics of developing or using chemical weapons.

There is still a tendency for engineering (and other professional) ethics to focus on legality and ignore the wider ethical implications of activities which may be legal, but which are not necessarily moral (Hersh, 2004; Seedhouse, 1988). There has also been an associated tendency, as illustrated by the case study presented above, to focus on how engineers carry out their activities, while frequently ignoring the nature of these activities. However, ethical behaviour requires both the action to be inherently ethical and to be carried out in an ethical way.

Another important factor is the precautionary principle (Dethlefsen et al., 1993; Hersh, 2006; Raffensperger and Tickner, 1999) which attempts to remove the need to prove a causal link between specific emissions and observed environmental damage before preventative and mitigating action is taken. Although the precautionary principle applies specifically to emissions, the principle of precautionary action and avoiding implementing activities with uncertain consequences could easily be extended to other types of risks. In addition, members of the public may be concerned about levels of risk which are considered acceptable by scientists or system designers. Lack of firm evidence of risk should not be mistakenly equated to lack of risk or used to belittle public concerns. Members of the public are generally more willing to accept or discount (uncertain) risks when the associated benefits are clearly apparent and valuable than when there are no obvious benefits. For instance, mobile phones have been widely accepted and used, despite the possibility of health risks (Blettner and Berg 2000), whereas there is considerable opposition to genetically modified organisms (Gaskell et al 2004), where the benefits, if any, are not apparent.

This implies that engineers should consider the wider and long term consequences of their work and both act to reduce any likely negative impacts and not undertake work where there are likely to be significant negative impacts the effects of which cannot be mitigated. The precautionary principle also implies that engineers should at the least be very cautious about undertaking work the future or wider impacts of which are uncertain.   .

There is a growing awareness of the importance of ethics for engineers and interest in the development of tools to support ethical behaviour. This includes the codes of ethics or professional conduct, developed by many science and engineering societies (Martin et al., 1996; Hersh, 2000a) and a variety of ethical theories, principles and methodologies. In many cases such theories and methodologies can be used to structure problems and highlight issues, but value judgements will be required to support ethical decision making. However, this growing awareness is still only reflected to a limited extent in engineering education. Relatively few programmes of engineering education at any level have a significant component on engineering ethics and even fewer, if any, try to integrate engineering ethics into all aspects of the curriculum.

The paper is set out as follows. The next two sections consider engineering and power; and barriers to ethical engineering respectively. The two middle sections discuss ethics and values and the perspective of the 'other'; and present the results of a small-scale survey of barriers and enablers of ethical behaviour respectively. The three final sections consider changing values through multi-loop action learning; individual and collective responsibility and the need for support; and present conclusions respectively

2. ENGINEERING AND POWER

There has been considerable discussion of the relationships between society, technology and science, but power relations have rarely been mentioned explicitly in mainstream advanced technology literature. One perspective considers technology to be neutral in itself and its consequences to be determined solely by the nature of particular applications. An almost diametrically opposed perspective, technological determinism (Ellul, 1954; Winner, 1977), considers technology to be all-powerful. In the strongest versions of this perspective technology totally determines the future directions of society in ways that are not possible to resist. Although useful, both these perspectives are too simplistic. In particular, they ignore the power relations and dynamics that effect choices about what technology is developed, how it is used and in whose interests it is deployed. These are highly complex processes that are difficult to address according to the positivism underpinning current engineering research (Jervis, 1997). Technology design and development are influenced by existing power structures and contribute to developing and further institutionalising particular structures (Baudrillard, 1999; Borgman, 1984).

Figure 1 illustrates the feedback relationships between science, technology and society and power dynamics and the fact that there are a number of different feedback relationships rather than either technology or social determinism holding. The model is a very simplified one based on the premise that developments and changes in both society and technology influence both existing power relationships and the state of science, as well as each other, through feedback relationships. In particular, there is feedback from technological development to social change, scientific development and power dynamics; and from social change to technological development, scientific development and power dynamics. An example of the the feedback and other mechanisms in this model is given in the following subsection.

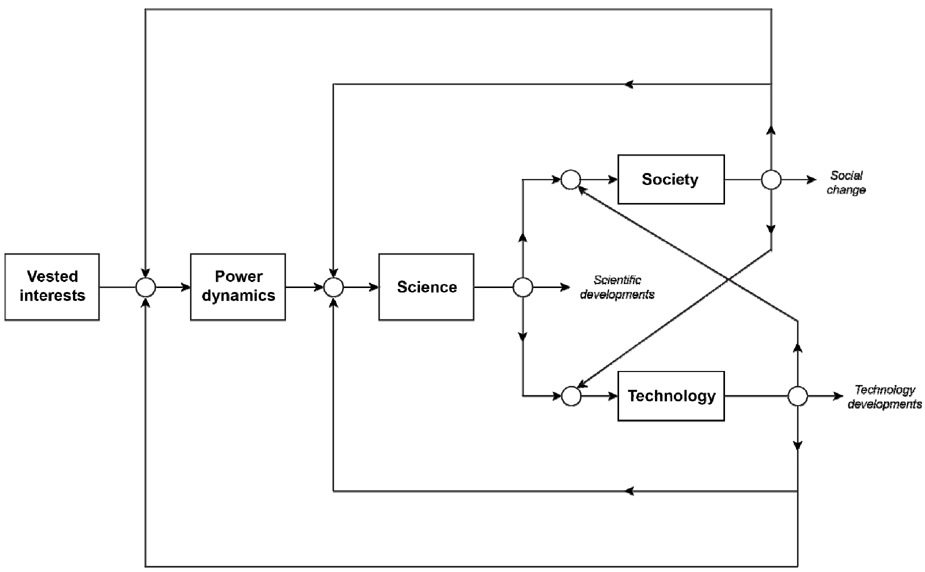

Figure 1, Feedback relationships between power dynamics, science, technology and society

It should be noted that, in addition to the other simplifications, the model is static rather than dynamic. I have chosen to present this simplified version due to the fact that the full model of these relationships is likely to be so complex as to obscure the main features. However, it should be noted that a number of additional factors or variables will affect the model, but have not been specified. These include unconscious and deliberate attempts to impose economic, political and ideological structures on technology development and engineering. These attempts could be considered a form of colonisation through technology, which is subtler, but no less insidious than previous attempts at colonisation (Banerjee, 2001).

It should be noted that the power structures associated with science and technology can act as barriers to ethical behaviour by engineers and other professionals. Other barriers to ethical behaviour are discussed in the next section. These power structures frequently act together with gatekeeping mechanisms (Hersh, 2005) that may block access to financial and other resources and rewards or even threaten engineers' and other professionals' careers. This leads to a range of concerns for engineers, scientists and other professionals, including the need to access resources in order to carry out their work, keep their jobs, progress their careers, and obtain financial and other rewards. These concerns all have a tendency to impose pressures on engineers and other professionals and may consequently act as barriers to an ethical stance. The existence of power structures both within organisations and in the wider society can also directly become barriers to ethical behaviour. This is particularly relevant in organisations with authoritarian management structures and cultures of blame i.e. a tendency to assume that if something goes wrong it must be someone's fault (or the fault of a group of people) and that they must be punished for it. However, cultures of blame are rarely also cultures of reward. Mistakes are noted and (heavily) punished, but there is little if any acknowledgement for doing things well. This is generally taken for granted and considered to be part of the job. This leads to several different types of barriers to ethical behaviour. Firstly, even if not exactly a climate of fear and suspicion, the workplace atmosphere is likely to be unfriendly if not openly hostile and there are likely to be strong pressures to not step out of line for fear of strong sanctions, including losing one's job. This will make it difficult for individuals to speak out and express concerns about the organisation's activities. Secondly, individuals are likely to be isolated from each other and to find it difficult to come together to provide mutual support. Thirdly a culture of blame and lack of recognition is likely to discourage professional ethics with regards to the way the job is carried out. People will be concerned with avoiding blame and there may be a feeling of pointlessness with regards to doing a good job, since no-one is going to notice.

Power structures in the wider society are one of the many, though by no means the only, factors that lead to individuals believing that decision making and influencing policy and events are the province of leaders and/or experts and not for them. This can lead to a feeling of powerlessness and apathy, which can act as a demotivator and reduce interest in ethical behaviour.

As this brief discussion indicates, it is more difficult for individuals to behave ethically when they are isolated and ethical behaviour is facilitated by having support, for instance from colleagues, friends or family, a trade union or a campaigning organisation. This support has a number of roles. Particularly where it is organised, as in a trade union or campaigning organisation, collective action is much more effective than individuals acting on their own. Contact with other people who share their views prevents 'dissident' individuals being psychologically isolated and as a result starting to lose confidence in their own values, beliefs and practices and abandoning them for the dominant ones. However, the value of collective action and support does not mean that individuals have no individual ethical responsibility The need for an appropriate balance between individual and collective responsibility is discussed in the penultimate section of the paper.

2.1 Example: Population Growth and Technology Development

This example is based on the extension of an application of feedback given in (Anon, 2012), and which also draws on the work of (Korotayev et al., 2006). The very high rates of global population growth in the 1970s have recently been correlated to non-linear second order positive feedback between technological change and population growth. Technological developments are leading to reductions in mortality and increases in lifespan and, to a certain extent, increasing the carrying capacity of the planet. However, there is a limit to the extent to which the carrying capacity can increase and, for instance, the global ecological footprint or total area required to meet global resource needs, absorb waste and provide space for its infrastructure already exceeded the earth's surface area by 21% in 2001 (Loh and Wackernagel 2004). This implies that the carrying capacity of the planet has also probably been exceeded and that increases in it are a damage limitation exercise rather than resolving the underlying problems of excessive resource use and waste generation. The increase in population is leading to new technological challenges and increasing the size and diversity of the talent pool available to work on these challenges and the number of potential investors and available resources to support this work. This is both leading to further technological developments and increasing the rate at which they occur.

These technological developments are reducing mortality and increasing life expectancy and, to some extent, the carrying capacity of the planet, but see comments above, which is leading to further technological advances. The developments in technology and the growth in population are leading to advances in science. Technological developments are providing new technological tools to support observation, pose new questions requiring scientific explanations and developments in science to fuel them. Population increases are leading to increases in the size and diversity of the talent pool as well as the financial and other resources available to support scientific research, thereby also leading to scientific developments.

Scientific developments are leading to technological developments, for instance by providing new knowledge and new areas of knowledge, which can be used to both improve existing technologies and develop new ones. Scientific developments are leading to population growth through improved health care and hygiene and increased knowledge about preventative measures. They may also be reducing the costs of health care and consequently the range of available health care measures and be reducing or even eliminating the unjust barrier posed by costs in countries in which health care is paid for directly by the user. This will generally result in a reduction in mortality and an increase in longevity. However, a range of social and political factors not shown in Figure 1, including poverty, reduce both the impact of improved health care and the ability of individuals to access health care, and therefore the effectiveness of this mechanism.

The impacts of scientific, technological and social changes and developments on power relations are probably much slower. However, scientific developments lead to new knowledge which may at least potentially challenge existing power dynamics and possibly change them. Population growth frequently leads to changes in the relative size of different population groups and consequently to changes in the power dynamics between them. Technological developments may affect power dynamics in a variety of different ways. For instance, developments in technologies of control tend to increase the power of elites and authoritarian regimes, whereas developments in technologies of information dissemination increase the power of ordinary people and dissident groups.

3. BARRIERS TO ETHICAL ENGINEERING

The philosophy of this paper is based on the premise that there are few genuinely ‘evil’ people, whatever is meant by the term ‘evil’. Instead, there are a number of barriers which make it difficult to behave ethically. Removing these barriers will make it much easier for individuals to behave ethically. This does not mean that individuals have no responsibility for their own behaviour, but that, as discussed in the penultimate section, it is much easier to behave ethically in a society which promotes ethical behaviour and where there is collective as well as individual responsibility.

When considering how best to implement policies and practices based on ethics, it can be useful to examine the barriers to behaving ethically and consider the means of overcoming them, as well as the enablers that support, motivate and encourage ethical behaviour. Power structures and their role in impeding ethical behaviour have already been considered in the previous section. Other barriers include the following:

- The fact that many unethical activities are both legal and highly profitable. The arms trade is a good or bad (depending on your perspective) example of this.
- Existing experience and expertise in unethical areas.
- Organisational cultures which do not prioritise ethics.
- Lack of recognition that some activities are unethical.
- Fear of the consequences, including job loss and the inability to obtain another one.
- Fear of standing out, social ostracism and/or being labelled as a troublemaker.
- Lack of support, the difficulty of standing on one’s own and the belief that it is not possible to make a difference.

The difference between legality and morality has already been discussed. For a number of reasons, discussion of which is beyond the scope of this paper, governments have frequently put more stress on regulating the way engineering (and other) activities are carried out than regulating which activities are permissible. Therefore, many activities which raise ethical concerns, such as developing and manufacturing new weapons systems, are perfectly legal. Many individual engineers or engineering firms will have worked in such areas for a number of years and have established experience, expertise and contacts, though they also have very valuable expertise which could easily be transferred to other areas of activity.

However, it could take a number of years for them to become known and respected in the new area and to return to their previous position. In addition, the new area could be less profitable, though considerably more satisfying. In some cases, individuals and organisations associated with unethical practices may be greeted with suspicion and have to work hard to establish their credentials. While such suspicion is understandable in the case of, for instance, a large oil company which sets up a few probably token environmental initiatives, it is undesirable in the case of organisations and individuals who are genuinely trying to change their core activities. This also raises the question of the value of apparently token environmental or other activities by organisations with a long history of environmental and human rights abuse. Should they be taken seriously or are they just intended to divert attention from other less ethical activities? When they are purely ended to act as camouflage for other activities, can they still have direct impacts which are of value?

The solutions to behaving ethically despite the existence of these barriers frequently involve changes in values and collective action and support, which will be discussed in subsequent sections. Only a brief overview of some of the barriers has been given in this section, as a later section will present the results of a survey on barriers to and enablers of ethical behaviour.

4. ETHICS AND VALUES: PERSPECTIVE OF THE 'OTHER'

In order to behave ethically it is necessary to determine what is and is not ethical. However, there is no consensus on this amongst the engineering community. While there is reasonable agreement as to what are unacceptable practices with regards to how work should be carried out, there is considerable disagreement as to what activities are ethical and which ones should be avoided. An example of this is military work, the ethical problems of which I have discussed elsewhere (Hersh, 2000b, 2003). However, a number of engineers consider military work justifiable or even laudable.

Engineers both need to be aware of their own values and the origin of these values in their own cultural and social identity and to be able to critique these values and consider enlarging them to cover additional ethical issues, since not all personal or societal values are necessarily ethical. However, an engineer's own values should generally form the basic starting point for ethical behaviour. Another approach would be to avoid any activities which could possibly be considered unethical or where there is public concern. The use of heuristic type approaches can also provide insight into your values. For instance, wanting to hide particular behaviours from significant others (or even casual acquaintances) implies that these behaviours are probably not in tune with your values and should be avoided. Consideration of both how you would like to be treated in a particular situation and trying to imagine the perspective of other actors and the likely differences in what they might want are useful.

Many approaches to ethics are both human centric and centred in the culture of the particular engineer. While human-centredness is likely to result in approaches which are more meaningful and more genuinely ethical than a focus on technology and/or organisations, it still has its limitations. In particular, there is also a need to consider other species and the planet, but not solely with regards to their relationship with humanity.

Approaches such as the Johari window can be used to support engineers and other professionals in determining their own values (Stapleton and Hersh, 2003). The theory of gestalt has been proposed as a means of considering the complex dynamics of engineering ethics (Stapleton and Hersh, 2003). Gestalt (Ihde, 1998) implies that the interpretation of an experience can change the experience itself. This makes it a useful theoretical approach to the subjective aspects of engineering ethics, particularly the culturally located aspects of ethics. It also supports engineers in examining ethics from multiple perspectives, including those of non-engineers and those who are different from them in other important ways. It can be used to give a focus to and make central the experiences of those who would otherwise be marginalised on account of social identity factors such as gender, race, disability, income, social position, sexual orientation or religion.

In many cases disagreement as to what is and is not ethical results from a narrow perspective that prioritises the interests and needs of the particular group(s) the person most strongly identifies with. This gives rise to a need for a much wider perspective which considers all possible actors, including other species and the planet, which may be involved in or affected by the proposed course of action and includes consideration of the perspective of the ‘other’, including minority groups or (majority world) nations with limited power. This change of perspective can support learning and understanding the nature of ethics and widening concepts of what is and is not ethical. In particular, it can be useful to consider the fundamental moral rights of the ‘other’, the avoidance of present and future harms to them (negative utilarianism) and the likely impacts on the character of both engineers and the ‘other’, including minority group engineers (virtue ethics) (Babcock, 1991; Lappé and Bailey, 1999; Madu, 1996; Martin and Schinzinger, 1996). A further useful consideration is the likely impact of any proposed actions on the relationships between the different actors and what types of actions are necessary to preserve or develop positive relationships (ethics of care) (Gilligan, 1982). This wider perspective is likely to ensure that few issues which have an ethical dimension are excluded and to result in a fairly strict interpretation of what is and is not ethical.

It should also be noted that there are parallels between ethical approaches based on an engineer’s own values and those based on those of the ‘other’ to etic and emic approaches to studying behaviour from outside and inside the (cultural) system respectively (Berry 1989; Brislin, 1970; Pike 1967). In particular, emic approaches are culturally specific and use criteria internal to the culture, whereas etic approaches involve theory building and generalisations across cultures and use criteria external to the culture.

In order to consider the perspective of the ‘other’, it is necessary to try and gain understanding of it and this will involve engaging with the ‘other’ in meaningful ways. Approaches which slow down discussion and encourage listening in order to support a genuine exchange of ideas and experiences are useful. A number of techniques have been developed. Many of them involve permission to speak being based on standing in a particular space or holding a particular object, which can range from a speaker’s wand or conch shell to a common every day object or light-weight article of clothing such as a hat or sweater. In addition to preventing interruptions and slowing down debate, the element of ritual can convey additional seriousness and importance.

The need to consider ethical issues from a wider perspective indicates the importance of critical thought and openness to new perspectives and challenging ideas. The abilities to think critically and challenge received wisdom are important factors in deriving a gestalt of ethics and recognising which values are truly ethical. Engineers need to be able to maintain their own ethical values and integrity in the face of challenges and pressures to confirm to organisational or societal norms which prioritise profit and convenience over ethics, particularly when the issues affect the environment or people who are not part of the dominant culture. They also need to recognise the need to go beyond minimal compliance with legislation and to be able to challenge and critically examine their own values and to modify, extend or reject them if they prove inadequate or even mistaken and in some sense unethical. Ethical engineers and scientists also need an appropriate combination of confidence and humility, the confidence to stand up for what they believe in and promote ethical values and behaviour in the face of opposition, and the humility to learn from other people, be open to new ideas and admit when they are mistaken.

Challenging negative concepts of the ‘other’ may be particularly important in technology transfer and other projects in majority world countries. The Bhopal accident discussed in a subsequent section gives a graphic illustration of the disastrous consequences of devaluing the ‘other’, leading to safety measures and training in the Bhopal factory of Union Carbide which were both deficient when compared to those in the West Virginia plant and totally inadequate to maintain a safe working environment. Thus, while technology transfer may be taking place in only one direction, it is important that learning and the transfer of knowledge take place in both directions. This is essential to ensure both that the minority world partner understands the requirements of the majority world partner and that the outcomes are indeed useful. However, it can also have considerable potential benefits to both partners in widening knowledge and understanding. The details of these benefits will depend on the context and the particular partners.

5, ETHICAL ISSUES FOR MINORITY WORLD ENGINEERS AND SCIENTISTS WORKING IN MAJORITY WORLD COUNTRIES

There is a limited body of work on ethical issues for minority world professionals working in majority world countries, often in the context of multi or cross cultural research. This work is spread across a number of disciplines, but has been treated differently in different disciplines with little cross fertilisation or attempts to draw together the different approaches. The main principles of these approaches (AIATSIS 2000; Pollard, 1992, 2002; Smith 2008; Tapp et al. 1974) are stated in terms of cross-cultural research, but are also relevant to other types of cross-cultural work, such as technology transfer projects. They are also relevant to research or other types of work with minority groups, such as disabled people (including in majority world countries). These principles, with the wording slightly modified to indicate that they do no just hold for researchers, include the following:

- Consultation, negotiation and mutual understanding.
- Respect, recognition and involvement, including learning about the host culture, language, history and social structure; seeking frequent guidance from the host community; and avoiding oversaturating any community.
- Avoidance of harm to the host community and ensuring real benefits to both the host community and researchers or other minority world personnel.
- Engaging only in actions that are ethically acceptable in both the researchers’ or other minority world workers’ community and the local community.
- Open communication and respect for participants’ rights. This includes avoiding subtle coercion, considering the power differences between participants and researchers or other minority world personnel, obtaining explicit permission to observe in private settings and protecting subjects’ and other majority world individuals’ welfare and dignity.
- Fostering the skills and self-sufficiency of host community scientists and engineers, who should, as far as possible, contribute equally to the research, technology development or other collaboration.

This list again illustrates the relationship between ethics and values. There may be differences of perspective as to ethical behaviour between researchers and the host community and the discussion of ethics and the perspective of the ‘other’ in the previous section is relevant. Both sets of values and perspectives on ethics need to be taken into account. For instance, particular issues may arise as a result of the differences between collectivist and individualist cultures (Hofstede, 1980). A particular example results in the case of procedures for obtaining informed consent. What is considered standard good practice involves providing full and honest information and seeking consent on an individual basis. However, this is based on an implicit assumption of individualistic cultural values, with personal information and (scientific) knowledge considered to be individual property. However, collective cultures have different values, which may lead to different ethical standards for carrying out research with regards to informed consent. For instance, some indigenous communities, including Australian Aboriginals, consider their knowledge and the results of research to be collective properties and have asserted their right to have ‘all investigations in our territories carried out with our consent and under joint guidance and control (Charter of the Indigenous Tribal Peoples, quoted in Smith 1999). This leads them to consider informed consent forms to be insulting and to consequently ignore them (Lincoln and Denzin, 2008).

Thus, this conflict of values leads to differing ethical requirements and needs a resolution. Researchers will require a degree of humility and openness to other cultures and ethical values rather than an automatic assumption that their accustomed procedures are the best and most appropriate ones. This is an example where it may be difficult to find solutions which take account of both local values and requirements and standard ethical practices. I would therefore suggest that the most ethical response should be based on local values and practices and that, in this case, the standard requirement for individual informed consent may act as a constraint and barrier to ethical practice.

The existence of sensitive, controversial and taboo issues is common to many cultures. However, there are often cultural differences in attitudes to specific issues, including those which are considered taboo or which respondents are reticent about discussing. This then raises issues of balancing the relative importance of cultural sensitivities and obtaining or expanding knowledge. The tendency may be for researchers to prioritise knowledge over local sensitivities. However, it should be recognised that this prioritisation is based on particular cultural values and may not be the most appropriate solution in terms of ethical action. On the other hand, it is often possible to investigate sensitive issues in ways that acknowledge and respect local values and sensitivities. Doing this may require in-depth knowledge of the local culture.

Other cultural differences which may have an impact on ethical research practice include the differences between high and low context cultures (Hall, 1976). Researchers and other professionals from low context cultures, such as Germany, the UK and the USA, may expect to proceed directly with the research or other work with limited time spent on greeting rituals, becoming acquainted and developing trust. However, respondents or researchers from high context cultures, such as the Arab countries, may expect to spend a considerable amount of time developing relationships and establishing trust before providing information or working together. In low context cultures, social relationships may also develop, but generally over a period of time as the work progresses, whereas in high context cultures the development of a degree of trust and some sort of relationship may be a prerequisite for the work starting. It is therefore important that researchers and other workers are aware of courtesy norms relating to greeting respondents and accepting hospitality from them (Malhotra et al 1996) so as to avoid both giving offence and impeding the development of trust and good relationships. They may also need to schedule additional time, particularly at the start of projects, in order to take account of this and accept that the additional associated costs are indeed essential.

The purpose of raising this issue is not to point to a unique well-defined solution or even a process for arriving at one. It is rather to highlight some of the principles which need to be considered in resolving complex ethical issues, which include the following:

- A holistic approach which considers all the issues.

- Consideration of how, for instance, to introduce a new technology to enable the local community to benefit from it without losing valuable features of its culture and lifestyle.
- Involvement of local people in the discussion and decision making.
- Consideration of the specifics of the particular situation.
- Developing an understanding of cultural beliefs and attitudes to technology to enable new technologies to be adapted to local behavioural patterns rather than trying to 'force fit' the local culture to the technology (Loch et al., 2003).
- Taking account of existing technologies and economic, cultural and social institutions and ensuring that all new technologies are compatible with them (Kransberg and Davenport, 1972).
- Openness to new perspectives and a degree of humility which recognises that you do not necessarily have all the answers.

Technology development and transfer projects need to consider the impacts of the technology on the local community and, in particular, its likely impacts on existing lifestyles. A particular example is given by information and communication technologies. On the one hand, there is a digital divide both between and within countries (Chen and Wellman, 2004) which disadvantages majority world countries and people lacking access to ICT in all countries, and access to information opens up a wide range of opportunities. On the other, the introduction of ICT may change the nature of social interaction, family and community life (Loch et al, 2003) and challenge existing religious and ethical values, though some of these values may be oppressive of particular social groups such as women. However, it should be noted that discriminatory values and practices are not the monopoly of any particular country and that, in practice, almost all countries exercise discrimination against some social groups, even if their publicly espoused values oppose all forms of discrimination.

Technology transfer projects need to consider sustainability issues, including the ability to produce, maintain and repair the technology locally. Where possible, locally developed rather than imported technologies should be used (Escobar, 1994). Although this is not the only solution which can ensure sustainability of technology use, local technologies are more likely to be compatible with local cultures and lifestyles, the state of local infrastructure and local climatic conditions. In addition, it is more likely that it will be possible to maintain and repair locally developed technologies locally. This is particularly important, since there are numerous examples of technologies which have been abandoned after a short period of use due to the inability to maintain and repair them. Continuing dependence on other countries for supplying, maintaining and repairing the technology is another and equally unsatisfactory possibility which may have a political or other price.

Technology development projects of limited duration need to consider what happens to the technology at the end of the project and, in particular, whether or not participants will continue to have access to it. When this is not going to be the case, it is important that this fact is clearly communicated to avoid false expectations and that the introduction and withdrawal of the technology are managed in a way that avoids dependence and disappointment.

Since discussion of research ethics tends to focus on research practice rather than wider issues, this will only be touched on briefly here. However, it should be noted that cultural and experiential differences need to be taken account of in research design and the interpretation of the results. This includes cultural differences in self presentation (Roberts et al, 2005), courtesy bias, reticence and any possibility of game playing involving misleading researchers. In addition, there may be difficulties with particular types of question format, reticence about particular topics and the fact that the survey or interviewing process may be an uncomfortable and unfamiliar situation for some cultural and ethnic groups (Malhotra et al, 1996).

I briefly discussed power relations in the context of technology towards the start of the paper. Power differences also affect research and technology development projects. While they have generally been considered between researchers and participants, they may also arise within research and other teams and between teams and external stakeholders due to factors such as status and job security (Easterby-Smith and Malina 1999). Personal characteristics, such as gender, disability, ethnic origin and country of origin are also associated with power differences and frequently also with discrimination and exploitation. While the details are beyond the scope of this paper, power imbalances of this type also have ethical implications and can affect the results of research. In general, researchers and technology developers are in a position of power relative to their respondents and prospective system users and this power difference is usually even greater in the case of informants from majority world countries and researchers and technology developers from minority world countries. However, situations occur in which researchers and professionals have what is considered a lower gender, class or ethnic origin status than respondents or are considered to be lower status due to disability or other factors. This admittedly relatively infrequent situation has received little attention (Mullings 1999).

5. SURVEYS OF BARRIERS TO AND ENABLERS OF ETHICAL BEHAVIOUR

5.1 Methodology

The survey was based on a questionnaire divided into three sections. Section A comprised personal information on gender, age, country, type of job, employment status and years of experience. Section B and C investigated barriers to and enablers of ethical behaviour, in general in Section B and for the specific case of minority world professionals working in majority world countries, including on technology transfer projects, in Section C. Both sections asked respondents to state what they considered to be the three major barriers and the three major enablers of ethical behaviour and evaluate the importance of barriers and enablers on a given list on a numerical scale. In both Sections B and C respondents were asked to comment on their answers and illustrate them by examples, as well as for examples of their own experiences of barriers and enablers and additional comments. Section C further asked whether they considered ethical behaviour more difficult for minority world professionals working in majority than minority world countries.

As this brief presentation of the questions indicates, the survey is highly subjective. The aim was to obtain an overview of the views of engineers and other professionals rather than statistical representative data. The survey also had the character of a pilot survey with the option of following it up with a larger scale survey if the results were considered to warrant further investigation. Therefore, the questionnaires were largely distributed through my contacts, including on a number of email lists, with requests to distribute the questionnaires further.

A contingency table X^2 test with five degrees of freedom software developed by Kirkman (1996) was used to investigate statistical significance at the 0.05 level. However, in several cases the presence of zeros across one or more row required data to be combined and a test with three or four degrees of freedom used. Due to length considerations, only an overview of the results will be given and most of the qualitative comments will not be discussed.

5.2 Results

19 replies were received from 11 different countries, with the largest response, seven (36.8%) from the UK (England), followed by two each (12.5%) from Poland and Ireland and one each (6.3%) from Austria, Germany, Kazakhstan, Macedonia, Saudi Arabia, Scotland, Slovenia, Wales, with the Slovenian respondent also working in Malaysia and one of the Polish respondents in the USA. The overwhelming majority (84.2%) of the respondents were male. While far from gender balanced, this is typical of the gender division in engineering in many countries. The respondents were all (very) experienced, with 15.8% having 10-20 years of work experience and 79.0% more than 20 years. They were spread amongst a number of sectors with 52.6% working in universities, 21.1% in industry, 15.8% in the voluntary sector or not for profit organisations, 5.3% in a school or college and 5.3% as independent craftspeople. Their employing or volunteering organisations also varied in size, with just over a quarter (26.3%) in each of the groups less than ten, 200-1000 and over a thousand workers (or volunteers), and 10.5% in each of the groups 11-50 and 50-200 workers. Employment status was also varied, with 52.6% employed by an organisation, 10.5% self-employed, 21.1% retired (one forcibly), 5.3% unemployed and 10.5% partially employed and partially retired, with one of the latter also volunteering.

All respondents provided what they considered the three main barriers and the three main enablers of ethical behaviour, though not all of them provided exactly three. Responses were very varied. The most commonly expressed barriers can be categorised as follows:

- Career related, including concerns about job security, income, promotion and personal ambitions.
- Organisational cultures and structures, including the colonialist policies of large hi-tech corporations and a lack of attention or respect for the needs of less powerful members of the organisation
- Lack of respect.
- Greed, profit, rapacity and business needs.
- External and peer pressures and pressures from the need for funding.
- Unwillingness to challenge unethical behaviours
- Lack of ethical oversight and review mechanisms

Less commonality was expressed on enablers than barriers. However, many of them fit into the following categories:

- A values driven organisational culture
- Job security
- Strong ethical leadership and a good example from senior personnel
- Personal ethical values, the desire to contribute to society and social and environmental concerns
- Respect for others.
- Clearly defined implementation plans for ethics policies.

Evaluations of the barriers and enablers on the list provided were each received from 18 respondents, though the missing respondent was not the same in the two cases. A few of the respondents did not provide scores for all the items.

Taking the averages over the number of responses obtained, with 0 indicating no barrier and 5 a very strong barrier, the strongest barriers are listed below with the average values for them given in brackets:

- Organisational cultures which do not prioritise ethics (4.35, 17 respondents)
- The belief that it is sufficient to comply with regulations even if the organisation's core activities are unethical (3.65, 17 respondents)
- The fact that some unethical activities are legal and highly profitable (3.61)
- The lack of education and training which promotes ethical behaviour (3.55)
- Lack of support, the difficulty of standing on one's own and the belief that it is not possible to make a difference (3.50).

This indicates that organisational cultures which do not prioritise ethics was considered the strongest barrier, followed by a group of four items. The difference between the average values for organisation cultures and two items in this group, sufficient to comply with regulations and lack of support were statistically significant (p=0.048 and p=0.02 repectively), whereas the differences relative to the other two items were not (p=0.44 and p=0.115). Additional data would be required to investigate further whether the four items do form a cluster with approximately equal values. There was a clearly statistically significant difference between the value of the lowest rated item, lack of strong enforcement of health and safety legislation (1.94) and both organisational cultures (p=0.002) and lack of support (p=0.032).

The strongest enablers, again with 0 indicating no enabler and 5 a strong enabler and their average values given in brackets, were considered to be:

- An education system which promotes ethical behaviour (4.29, 17 respondents)
- Support from management for ethical behaviour (4.28)
- Support from colleagues for ethical behaviour (4.22)
- A culture which acknowledges achievement and encourages people to learn from their mistakes rather than applying blame (4.12, 17 respondents)
- Recognition that the ethical nature of core activities is just as important as the way these activities are carried out (4.06, 16 respondents).
- Encouragement to discuss ethical issues (4.0, 17 respondents)

Although the highest value was given to one of the barriers, overall slightly higher scores were given to enablers than barriers and this difference was statistically significant (p=0.001). The values of all these items are fairly closely grouped together and the differences in the values of the highest and two lowest items on this list are not statistically significant (p=0.36 and p=0.26 respectively). Additional data would be required to determine whether this is a cluster or ordered list. There is a large gap between this cluster or list and the next item, the availability of materials and training workshops on ethics (2.94), but the difference is not statistically significant (p=0.087), though this is probably an artefact of the relatively small sample size. However, the distance to the item with the lowest evaluation, the existence of an ethics policy (2.71) is statistically significant (p=0.019). The difference between the last two items was also found to be statistically significant (p=0.029). The low value assigned to the existence of an ethical policy seems surprising, but probably indicates that respondents considered that an ethics policy on its own is insufficient and that a range of other and more proactive measures are required.

Over half (57.9%) of respondents were unsure whether or not it was more difficult for minority world professionals to be ethical when working in majority than minority world countries, 26.3% considered it was not, 10.5% that it was and

5.3% did not reply. Most of the explanations of the 'no' answers were of the type 'people are the same everywhere' or mentioned individual characteristics. A few respondents mentioned corruption and one respondent 'the individuals, the specific context, and an understanding of the host culture, as well as a general willingness not to attribute all problems to the ethical shortcomings of the local population'. The respondents who considered that it was more difficult to be ethical in majority world countries related the differences to lack of understanding and identification with the local context - 'they cannot think as citizens', 'power and authority' and considered that 'this is more subtle in the developed world but can be quite unjust and unethical processually'.

Eleven respondents (57.9%) evaluated the barriers to and 10 respondents (52.6%) enablers of ethical work in majority world countries and not all of them evaluated all the items on the two lists. Due to the relatively low number of responses to these questions I did not investigate statistical significance. The most significant barriers were considered to be:

- The organisation's lack of respect for the local people (3.60)
- The organisation's lack of knowledge or understanding of the local culture (3.40)
- An organisational culture which promotes exploitation of majority world people (3.33)
- Arrogance (3.22).

The most significant enablers were considered to be:

- Projects developed co-operatively with local people (3.70)
- Recognition of local expertise and willingness to learn from it (3.70)
- Organisational policies which actively promote the employment of local people and measures to ensure no discrimination against them or minority groups of workers (3.40)
- Organisational recognition of the importance of considering the impacts on and benefits to local people and the local environment (3.40)
- Organisational ethics policies which promote fair trade (3.33, 9 respondents). However, it should be noted that one respondent questioned whether it was 'a semi-commercial label with all sorts of associated "baggage"? Or ethical commerce … ?' Clearly the latter was meant and understood by most respondents.

5.3 Brief Discussion of the Results

Responses were obtained from a varied sample of engineers and associated professionals, though biased towards men and those with significant experience. Considerable rich data was obtained, not all of which it has been possible to explore here, and it would seem worth carrying out a large scale survey. As is to be expected, respondents expressed many different points of view, but in general seemed to accept the premise of organisational and societal barriers to and enablers of ethical behaviour. Particular barriers related to concerns about job security and career development, unethical organisational cultures, external pressures of various types, greed and the profit motive, the lack of education and training which promote ethics, lack of support, the fact that many unethical activities are both legal and profitable and a focus on compliance with regulations rather than making the organisation's core activities ethical.

Many of the enablers were opposites of the barriers. This includes a value driven organisational culture which recognises achievement and encourages people to learn from their mistakes, strong ethical leadership and implementation plans for ethics policies, support from colleagues and management, job security, an education system which supports ethical behaviour, recognition of the importance of core activities being ethical, personal ethical values and respect for others. Interestingly having an ethical policy received the lowest score amongst the enablers, possibly indicating that, though such policies are essential, they are not sufficient on their own to make a significant difference.

Just over half the respondents were unsure whether it was more difficult to be ethical for minority world engineers when working in majority world countries, but a significant minority thought it was not. This response was based on individualistic approaches to ethics, despite the previous recognition of the importance of barriers. I would suggest, though this needs investigation, that there may be more temptations and less oversight of minority world engineers in majority world countries. In addition, the unfamiliarity of the situation can lead to challenges and temptations. The main barriers to ethical behaviour in majority world countries were considered to be the organisation's lack of knowledge, respect and understanding of the local people and environment and arrogance. The enablers were again largely the opposite of the barriers, involving respect and willingness to learn from and involvement of local people in projects and consideration of local impacts.

6. CHANGING VALUES: MULTILOOP ACTION LEARNING

Multi-loop action learning, which is illustrated in Figure 2, is one of the techniques which can be used to support learning and changing values. It seems to have developed incrementally. First order or adaptive learning applies negative feedback to mental models (Hersh, 2006) or conceptualisations of situations to change responses and move closer to the desired goals (O'Connor and McDermott, 1997) and, for instance, to modify solutions that have not worked well in the past. However, adaptive learning is unlikely to be successful if the underlying problem is with the existing mental model (Hersh, 2006). In this case, double loop learning with a second negative feedback loop can be used to change existing mental models. Using negative feedback to revise mental models can remove the barriers to understanding the underlying causes of social or environmental problems or unethical behaviour as the first stage in resolving the problems or changing the behaviour (O'Connor and McDermott, 1997). Triple loop action learning (Nielson, 1996) adds a third feedback loop in order to achieve changes in the underlying tradition or ethos of an organisation. Quadruple loop action learning (Hersh, 2006) adds a further loop in order to challenge and change the ethos or values of the surrounding society or alternatively the underlying nature of the organisation in addition to its practices.

This potential for change of the four different types of action learning is illustrated in figure 2 and can be summarised as follows:

- Single loop action learning is about changing behaviour, rather than learning about ethics and changing values.
- Double loop action learning involves changes in values (generally of individuals) as well as behaviour.
- Triple loop action learning involves changes in the underlying tradition or ethos of the organisation, as well as changes in values and behaviour.
- Quadruple loop action learning involves changes in the ethos or tradition of the surrounding society.

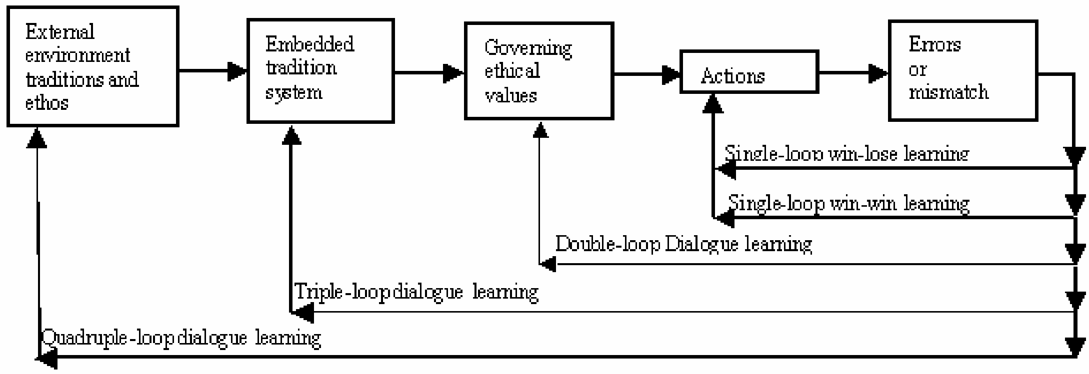

Figure 2, Multi-loop action learning

An important feature of multi-loop action learning is the nested nature of change at different levels and the associated recognition that changing values at a particular level is going to be difficult without appropriate changes at the higher levels. For instance, it is possible, but not easy for individuals to change their values in ways which are counter to the ethos of their organisation and the values of their society. Equally, for changes in values at the organisational and societal levels to be meaningful and to have an impact, there also need to be changes in values at the individual level and changes in behaviour. A number of methods are available to support single, double and triple loop action learning (Hersh, 2006). In the case of quadruple loop action learning, methods to achieve change largely involve campaigning of different types, including letter writing, leafleting, events, lobbying, direct action and industrial action. Some of these methods may also be required to achieve change at the third loop organisational level. Currently multi-loop action learning maximally involves four loops. However additional loops could be added to represent changes at further levels, for instance at the national, regional and global levels, or within a particular community the organisation is based in and in the wider society.

Change frequently happens at the margins (Hersh and Moss, 2004). This is where women and minorities are situated. It may be easier for engineers who are 'marginalised', for instance on account of gender, race, sexual orientation, disability or the nature of their primary expertise, to see the need for change, including in the nature of the organisation's activities, but they may be even more vulnerable to punitive sanctions, such as dismissal, than their more mainstream colleagues. Deliberate or unintentional gatekeeping processes also frequently act as filters to prevent innovation from minority or marginalised groups.

This is also interesting in the context of work by minority world engineers in majority world countries, who at least in some senses could be considered to be working at the 'margins'. In addition, even in their own countries majority world engineers and other professionals can also be considered to be at the margins, as they may act as an interface between minority world engineers and the non-engineering population in their country. They may also unfortunately be accorded lower status than majority world engineers and be effectively treated as something between a professional engineer and a non-engineer lay person. This marginalisation and the limited attention and respect frequently given to their knowledge and expertise may impede positive change. In addition, this ignoring and devaluing will limit the benefits which would otherwise occur from the interaction of people with different types of knowledge.

Real technological and social change require learning at all loop levels, including triple and quadruple loop learning. This is required to change the ethos of organisations (triple loop learning) and of society as a whole (quadruple loop learning) to allow us all to benefit from the knowledge and expertise that is currently sited at the margins. Nielson (1996) has suggested some methods that can be used to achieve triple loop learning, but they will not always work. The problem of quadruple loop learning or changing deep seated attitudes in society as a whole is generally even more difficult to resolve. In practice change occurs slowly and not necessarily linearly. It should also be noted that once such change occurs the margins will have shifted and new sources of creativity and learning will be required to achieve significant change and innovation. This gives an iterative process which should continue until the occurrence of convergence to a state in which significant change is no longer desirable. Quadruple action learning also shows the relationship between changing values at the individual and societal levels. In particular, it is much easier for engineers to change their values in line with rather than against existing trends. However, it may often be necessary for engineers to change their values counter to existing trends. In addition, engineers who change their own values should also consider trying to change the values of their organisations and the wider society. This is much easier to do with the support, for instance, of colleagues, a trade union or campaigning group than as an isolated individual.

6.1 Example: Bhopal

As an example of multi-loop action learning, I will now consider the case of how action based on the different loops of multi-loop action learning could have been used to prevent the catastrophic accident at the Union Carbine plant in Bhopal, India in December 1984, in which a leak of the toxic chemical methyl isocyanate exploded and 40 metric tons of deadly gas were released. As a result an estimated 3800 people died immediately, about 10,000 in the next few days and another 15,000 – 20,000 deaths occurred over the following two decades. Compensation was received by 554,895 people for injuries and 15,310 survivors of the dead, though the average amount received by families of the dead was very small at $2,200 (Broughton, 2005). This accident and some of the contributory factors are discussed from a human factors and lack of safety culture perspective in (Hersh, 2006) and these contributory factors will be summarised briefly below.

By the late 1970s operations had changed from mixing chemicals to producing chemical ingredients. However, not all the safety mechanisms in use in the USA were transferred, though Union Carbide was aware of the hazards. For instance, at Bhopal safety controls were manual and workers detected leaks by smelling them, whereas the West Virginia plant used computerised instruments. Safety practices eroded from US to lower Indian ones and little attention was given to a 1982 report by US engineers which mentioned many of the hazards that led to the disaster. Most managers and workers were inadequately trained in the relevant health and safety issues and most workers had little technical education. All signs about operating and safety procedures were in English, which many of the operators did not understand. Due to the lack of air conditioning workers did not always wear safety gloves and masks. Organisational rigidity was largely responsible for both the lack of effective measures to deal with the five major accidents between 1981 and 1984 and the lack of improvement in safety measures to prevent further occurrences.

At the time of the accident the main defence against gas leaks, a vent gas scrubber designed to neutralise the gas, was turned off due to a temporary halt in production of methyl isocyanate and turned back on too late to be of use. The flare tower to burn off escaping gas missed by the scrubber was inoperable, as a section of pipe connected to the tank was being repaired. The pressure valve to indicate a leakage of gas was located away from the control room and had no link to it. Therefore, the leak did not appear on monitors in the control room. Excessive work loads made it difficult for control room operators to check all the control room panels and lack of oxygen masks led to their exodus as gas levels increased. The numbers of deaths and injuries were greatly increased by the presence of large numbers of poor migrant workers squatting round the plant in the hope of getting a job or using the plant's water and electricity.

This is an example of problems and a need for change in all the loops. At the first loop level there were serious problems with safety practices by workers and management, management practices and human factors issues and a lack of training. At the second loop level, the values of both workers and management do not seem to have prioritised safety, training or knowledge about plant processes. However, this is hardly surprising, since at the third loop or organisational level Union Carbide seems to have had an ethos which valued Indian workers less than US workers, took safety issues and workers' welfare at its Indian plant (Bhopal) less seriously than at its US plants, totally ignored its responsibility to act on (serious) safety warnings and did not have a real understanding of the local context. At the fourth or societal level there seems to have been an acceptance that many people in India were desperately poor, possibly combined with a tacit belief that the life of the average person in India was of little value, and an acceptance of lower safety standards and less training in minority than majority world countries.

This example also illustrates the need for changes at all levels. Changes in practices by individual workers and managers to improve safety, training and labour relations and reduce rigidity are unlikely to be successful or sustained without changes in values by individuals and a change in the ethos of the organisation. Changes in values at the individual level would be insufficient without organisational support due to the need for access to resources and information and the possibility of workers (or managers) being disciplined or even dismissed if the increased concern for safety is perceived to threaten profits. Changes in values at the organisational level would also be insufficient without support from workers and managers, who might otherwise actively or passively obstruct moves to improve safety. The need for changes in values at both the individual and organisational levels is also related to the need for both individual and collective responsibility discussed in the next section. A change in values at the societal level can reinforce the changes at the individual and organisational levels through the provision of resources and societal approval or disapproval. In addition, legislation would provide support for good practises which might otherwise be difficult to sustain or impose them where the organisational will is lacking.

Almost all accidents are preventable by appropriate measures, particularly with hindsight. However, in this case a change in values at the societal, organisational and individual levels to recognise that safety is just as important in India as in the USA and a commitment to implementing the associated standards and practices would have probably sufficed to achieve an appropriate safety culture and implement the necessary safety measures. Unfortunately, this did not occur and a tragic accident was the result.

7. INDIVIDUAL AND COLLECTIVE RESPONSIBILITY: THE NEED FOR SUPPORT

Ethical behaviour and social responsibility are both an individual and a social or collective responsibility. As has already been indicated, ethical action is often most effective when taken collectively and collective action can reduce the likelihood of victimisation. Collective support for ethical behaviour is particularly important in the current economic climate with reduced job security and reduced availability of new jobs. However, the literature on engineering and ethics frequently focuses on the individual, but this individualisation of ethics has its dangers. For instance, De Maria (1992) suggested that this lone voice aspect often puts whistleblowers (who disclose information about activities in their organisations) in a particular conservative political context and can allow them to be recruited back into the system through internal disclosure. Bok (1981) concurred in this view that open door policies to encourage internal disclosure can turn into traps if the abuse is planned by those in charge.

De Maria (1992) also recognised the value of collective action, though his proposals that governments should encourage collectivised workplace dissent or whistleblowing as a class action in addition to protection for individual whistleblowers are unlikely to be adopted by governments or organisations trying to coopt whistleblowers and limit the effects of their disclosures to correcting specific abuses. However they do indicate that a collective approach to engineering ethics could support real change.

On the other hand, the need for collective approaches does not remove individual responsibility. Collectives are composed of individuals who need to take ethical responsibility and behave ethically both as individuals and as members of organisations. However, ethical initiatives by individuals have a much greater chance of achieving success if supported by any organisations or other ‘collectives’ of which they are part. Therefore, engineers who are concerned about ethical issues will be more effective if they can convince their colleagues to share their ethical concerns and act on them, as well as reducing the likelihood of their victimisation. Support from the collective is also important to enable ethical engineers to retain confidence in their own values when these are counter to those of the organisation, and possibly even those of the majority of their colleagues, and to reduce the risk of them adopting the dominant values and/or being co-opted. However, ethical engineers may find it difficult to persuade colleagues who are concerned about their careers to support them, particularly in questioning the nature of the organisation’s activities rather than just how they carry them out. When, as is frequently the case, these activities are legal, the difficulties of obtaining support may be increased. Thus, it may be more difficult to oppose a firm moving into or continuing in the arms trade than taking bribes, presenting false tax returns or engaging in other corrupt and generally illegal practices.

I would suggest that the collective element of ethical responsibility means that in addition to being responsible for their own behaviour, individuals have a degree of responsibility for trying to influence the values and behaviour of their colleagues and their organisation. This raises a number of issues, of which only two will be briefly considered here:

- Whether it is preferable for ethical engineers to look for ethical employment rather than trying to change unethical organisations from within.
- The trade-offs between risk and ethical responsibility e.g. what is required of an ethical engineer with regards to drawing attention to and trying to prevent unethical behaviour, when doing this may risk job loss or even physical violence.

As is frequently the case, such questions do not have simple answers and there is considerable uncertainty. For instance, it is necessary to estimate the real possibilities of changing an unethical organisation rather than either being co-opted or bruised by the struggle and possibly ending up unemployed. There is also the issue of the availability of ethical employment in the unethical organisation and whether their work will contribute to the unethical activities of the organisation to any extent. On the other hand, there are few organisations which are totally ethical and there may be the possibility of making significant positive changes. In making decisions of this type engineers and other professionals also need to be aware of their values, what they are trying to achieve in their working lives and the extent of the risks, particularly of job loss, they are willing to face as a result of trying to change the organisation. However, very few jobs are now totally secure.

While receiving support from the collective, it is important that individuals both maintain their own judgement rather than submerging it in the collective and are open to other perspectives, particularly those of social groups and individuals who are frequently marginalised. In extreme versions this relinquishing of individual judgement to the group can lead to the formation of a mob. This relates to Kakar's (1996) theories of the development of crowd formation in Hindu-Muslim riots in India in which periods of social tension and precipitating event(s) led to group 'fusion' based on stereotypical images of the self and the 'other'. This resulted in the individual submerging their identity in that of the group, acting stereotypically and in accordance with the behaviour expected of a mob acting against a particular stereotyped scapegoat, in Kakar's discussion, Muslims or Hindus.

The solution involves transforming the individual-group dynamic to eliminate (or at least reduce) the various pressures on individuals to submerge their identities and judgement in the group to avoid becoming stereotyped, excluded and/or scapegoated. This does not mean relinquishing a group identity and identification in order to retain the individual identity, but rather maintaining the necessary dynamic and creative tension between individuals and the group. This could then lead to a strengthening of both individual judgement and values and the support available from the group. This transformation will require a strengthening of both the individual and collective sense of responsibility for ethical behaviour, the maintenance of individual identity within the collective and tolerance and respect for diversity. This will then give rise to a community of distinct and diverse individuals based on mutual respect.

A prerequisite for this type of positive individual-collective dynamic is strengthening the sense of both individual and collective identity. It will also require a transformation of the definitions of communities of different types based on inclusion rather than exclusion. This transformation will also require the concept of the 'other' to be challenged. In this way the 'other' becomes someone to be learned from and a source of cultural richness, creativity and growth rather than an outsider to be excluded, discriminated against, exploited and/or scapegoated. The development of support mechanisms at the collective level for individuals and organisations trying to act ethically will help individuals resist pressures towards conformity with unethical group norms and behaviour. It may also provide support for individuals or particular groups accepting responsibility for the results of their own unethical behaviour and trying to mitigate its consequences rather than shift responsibility.

There is therefore a need for support mechanisms to ensure that engineers who express dissent are not marginalised or victimised. This should include support from the engineering community against victimisation of engineers who express concerns or take action motivated largely or solely by ethical considerations. This support should be available without necessarily requiring the engineering community as a whole to share the ethical principles of the engineer(s) taking the action. Thus, for instance, it should be possible for engineers taking action motivated by genuine ethical concerns about nuclear or other weapons to receive support against victimisation even if the engineering community as a whole does not share these concerns.

8. CONCLUSIONS

The paper has discussed the limitations of existing implementations of engineering ethics, which focus on how activities are carried out rather than whether they are ethical in themselves. The importance of engineers both being aware of their own values and being able to critique them was noted.

This led to the following central ideas of the paper:
1. The need for engineers to be both aware of and able to constructively critique their own values.
2. Overcoming the limitations of ignoring whether actions are ethical in themselves and considerations of ethical values by extending them to take account of the perspective of the 'other', including the environment and minority and marginalised groups. The importance of critical thought and openness to facilitate this and the use of multi-loop action learning as a technique for achieving this change were noted.
3. The dynamic relationship between individual and collective responsibility and the importance of support for ethical engineers. The importance of engineers maintaining their own judgement and not submerging it in the collective were noted, as well as the redefinition of engineering (and other communities) based on inclusion not exclusion, so the 'other' becomes someone to be learned from and a source of growth.
4. The importance of organisational, structural and contextual factors which can act as barriers to and enablers of ethical behaviour.

These barriers and enablers were investigated through a survey. The results indicated the importance of both organisational and personal ethical values, as well as the need for support from both colleagues and management, respect for others and job security as enablers of ethical behaviour, and the lack of these things as significant barriers.

In the context of minority world engineers working in majority world countries a lack of knowledge, respect and understanding together with arrogance were considered the main barriers to ethical behaviour. On the other hand, involving local people, considering local impacts, respect for local people and a willingness to learn from them were considered the main enablers.

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